- Increased potential for fugitive dust, proportional to the area of disturbed ground surface;

- Potential for invasive species being established in disturbed areas before indigenous vegetation can be reestablished;

- Potential for bird strikes, generally proportional to the number of turbines installed;

- Increased time required for construction, with proportional increases in both the magnitude and duration of impacts related to construction;

- Potentially additive impacts from individual turbines, including noise and viewshed impacts; and

- Proportional increases in O&M costs, including costs to deal with wastes associated with system maintenance and repair.

D.6 COMMERCIAL WIND ENERGY INDUSTRY PROFILES

This section provides an overview of the existing commercial wind energy industry within the study area. The AWEA compiles and maintains data on commercial wind farms.[21] The review and analysis of these data provide a reasonable basis from which to anticipate the characteristics of future wind farms.

Industrywide reviews of the commercial utility-scale wind energy industry have identified the following important trends, each of which will greatly influence future wind farms.

- In general, average individual wind turbine power-generating capacities have steadily increased in North America, from 500–750 kW in the late 1990s to megawatt-capacity turbine installations beginning in 1999, resulting in typical wind farm generating capacities of 50 MW or larger (Kaygusuz 2004).

- The (worldwide) average growth rate of the cumulative installed wind energy power-generating capacity over the period 1998 to 2004 has been about 30% per year (Kaygusuz 2004).

- As the understanding of aerodynamics has been increasing and as designs have been defined, wind turbine efficiencies have been increasing, especially for turbines with larger rotor-swept areas. Average annual yields per unit of rotor-swept area (RSA) have increased by more than 50% as rotor diameters have increased from 66 to 262 ft (20 to 80 m) (Milborrow 2002).

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[21] The text box on the next page describes the AWEA and information compiled by the AWEA regarding the wind energy industry.

- Wind turbines now have power-generating capacities of as much as 600 W/m^2 of RSA.
- Three-bladed, upwind turbines dominate the commercial utility-scale market (Milborrow 2002).
- The majority of wind turbines run at fixed rotor speeds and utilize induction generators. However, newer models equipped with sophisticated electric power conditioning controls have rotors that run at a variable rotational speed (Milborrow 2002).
- Newer-model turbines tend to run at slower rotor rotational speeds but have relatively high energy capture/conversion efficiencies (Milborrow 2002).

About the AWEA

The American Wind Energy Association (AWEA) is a national trade association that represents wind power plant developers, wind turbine manufacturers, utilities, consultants, insurers, financiers, researchers, and others involved or interested in the wind energy industry. The AWEA provides up-to-date information on wind energy projects operating worldwide and projects under development, and it conducts technology and policy development activities related to wind energy.

The AWEA compiles and regularly updates relevant domestic and worldwide statistics on the wind energy industry and makes them available to industry participants, the interested general public, and the news media. These data are available at the association's Web site at http://www.awea.org. Also available on the AWEA Web site is access to various wind-energy-related information resources, including wind energy fact sheets and a catalogue of related publications. The AWEA also publishes a weekly newsletter devoted to wind energy news and hosts an annual national conference, WINDPOWER. Detailed information on AWEA activities and services can be obtained by visiting the Web site.

Information developed by the AWEA has been incorporated into this PEIS without independent verification. The BLM does not endorse the AWEA and does not make any warranty regarding the accuracy or completeness of the data it provides.

Although the commercial wind energy market in the United States has existed for some time, it has only recently (since 1999) begun to experience substantial growth, with calendar years 2001 and 2003 witnessing the two largest single-year's growth. Figure D-6 graphically depicts the rise in wind energy capacity (nameplate ratings in megawatts of electricity; the bars in the foreground represent capacities added annually; the bars in the background represent cumulative power capacity) over the period from 1981 through 2003. Data published by the AWEA indicate that the total installed capacity for all domestic commercial wind energy as of December 2003 was 6,374 MW, with 1,687 MW coming on line in 2003, which was a 36% increase from the capacity at the previous year's end (AWEA 2004d). Calendar year 2003 compared favorably with the previous year, showing a worldwide increase in capacity of 6,868 MW to reach a total of 31,128 MW and a U.S. increase of 410 MW to reach a year-end total of 4,685 MW, which represents 15% of the world's market (AWEA 2003a). Of the current total domestic capacity of 6,374 MW, 2,999.7 MW (or 47%) is being produced in the 11-state study area of this PEIS. The increase in overall generating capacity has been accompanied by a steady increase in individual turbine proportions and capacities. In the late 1980s, average turbine power outputs averaged 450 kW. Outputs increased to an average of 600 to 750 kW by the late 1990s. Now, individual turbines with ratings greater than 2 MW (2,000 kW) are commonplace (McGowan and Connors 2000).

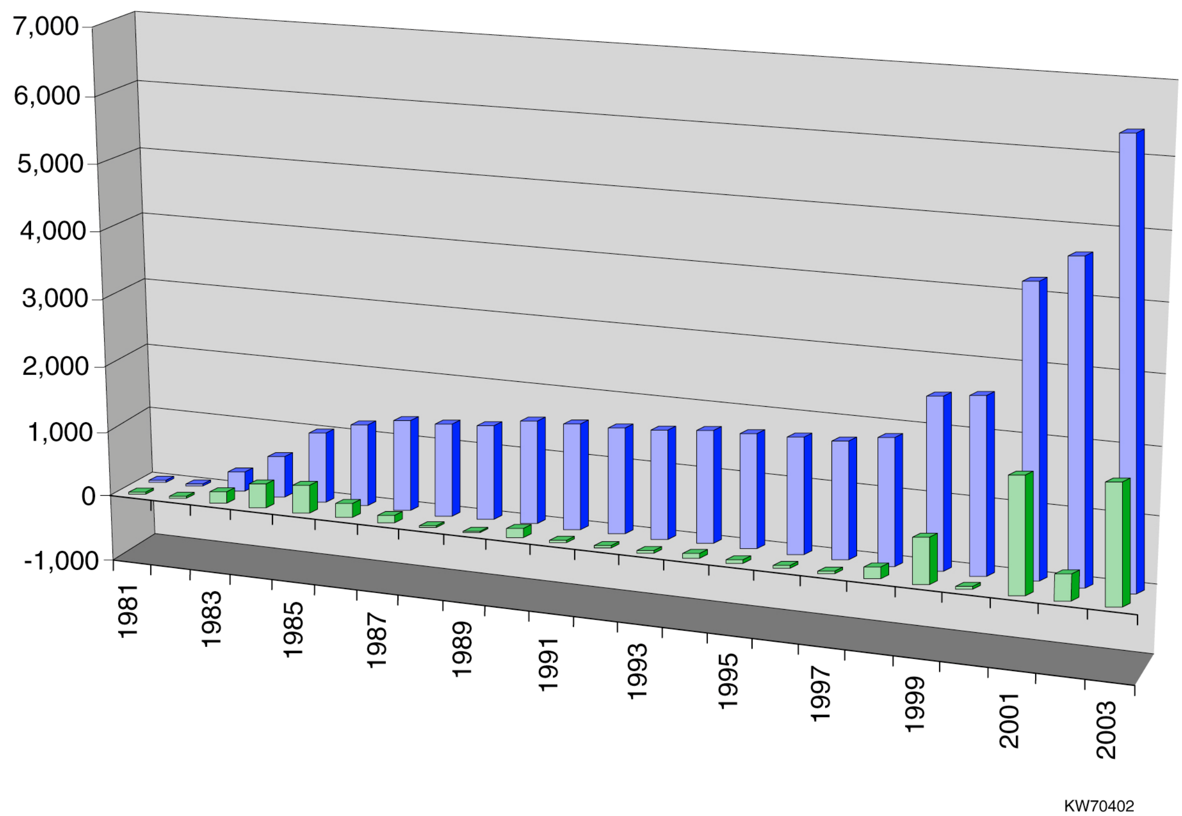

FIGURE D-6 U.S. Installed Capacity (MW) for 1981 through 2003 (Source: AWEA 2004d. Reprinted with permission. Courtesy of the AWEA.)

Figure D-7 shows the distribution of wind energy power-generating capacity across the United States. The numbers represent power capacities of utility-scale wind farms only, all of which deliver power directly to the electric power transmission grid. Additional power capacities from distributed energy systems are not included. The power capacities represent nameplate ratings and are rarely realized in practice. (See the discussion on typical capacity factors in Section D.5.2.) Within the 11-state study area for the PEIS, the total installed wind energy capacity is 2,999.7 MW.

Table D-1 lists the commercial wind energy projects completed in 2003. Projects completed within the 11-state study area are in bold type. The projects listed in the table represent new wind farms and phased expansions, or "repowering" of existing wind farms (i.e., replacing existing turbines with ones of newer design). Facility expansions and repowering activities are not expected to have the same array and magnitude of impacting factors as would a completely new facility. By definition, such site modifications are outside the scope of this PEIS.

In general, the number of manufacturers of wind turbines has greatly decreased from earlier years. In fact, a number of manufacturers have gone out of business. However, also represented in this decline are a number of mergers among manufacturers.

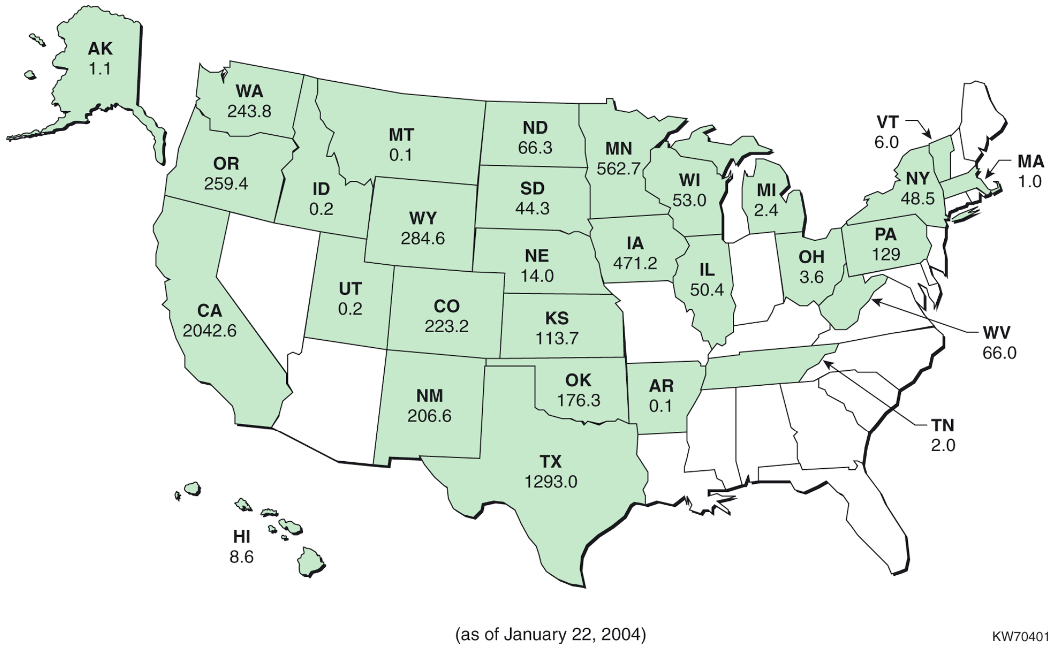

FIGURE D-7 Wind Energy Projects in the United States (Source: Adapted from AWEA 2004a. Reproduced with permission. Courtesy of the AWEA.)

Table D-1 lists the manufacturers of commercial wind turbines whose products were installed in U.S. wind farm projects in 2003. Although there are many other manufacturers, those listed in Table D-1 nevertheless represent a cross section of vendors. One should therefore take a more careful look at the turbine models offered by these vendors. Table D-2 lists the ranges of values for critical parameters of wind turbines installed in 2003. Although it is assumed that installations in 2003 constitute a reasonable representation of the most current facility installations and expansions, there is still a possibility that future wind farms will utilize turbines from other manufacturers. Nevertheless, it is reasonable to assume that the turbines installed in 2003 met the technical requirements of the sites at which they were installed. It is therefore also reasonable to assume that future developments at sites with similar wind regimes may also utilize turbines with these approximate specifications.

It is not the BLM’s intention to endorse any specific equipment manufacturer.[22] Consequently, rather than present the specifications of individual turbines, the table displays a range of values for each parameter that is addressed. Only design specifications that were readily available from manufacturers’ Web sites are included in the range calculations. Not always accurately reflected in the range value displayed, but nevertheless important for anticipating future wind farm characteristics, is the fact that many manufacturers offer modules rather than complete turbines, providing a number of options for each major component. Thus, the developer can custom build a turbine that is precisely suited to a particular site’s wind conditions and to the

22 For a comprehensive list of turbine manufacturers, consult AWEA (2004b) or commercial business source guides such as Momentum Technologies, LLC (2004).

TABLE D-1 Wind Energy Projects Installed in 2003[a]

State	Project Name	Location	Capacity (MW)	Developer	Turbine Manufacturer	No. of Wind Turbines
Alaska	Selawik Wind Project	Selawik	0.2	Kotzebue Electric Association	AOC	4
Arkansas	Bitworks	Prairie Grove Industrial Park, Washington County	0.1	Bitworks, Inc	NEG Micon	1
California	**High Winds**	**Solano**	**162**	**FPL Energy**	**Vestas**	**90**
California	**Mountain View III**	**San Gorgonio**	**22.44**	**PPM Energy**	**Vestas**	**34**
California		**Sacramento**	**9.9**	**SMUD**	**Vestas**	**15**
California	**CalWind II CEC-repower**	**Tehachapi**	**8.58**	**CalWind Resources, Inc.**	**Vestas**	**13**
California	**Whitewater expansion**		**4.5**	**Cannon Power Corp.**	**GE Wind**	**3**
California	**Karen Avenue II**	**San Gorgonio**	**4.5**	**San Gorgonio Farms**	**GE Wind**	**3**
Colorado	**Colorado Green**	**Near Lamar**	**162**	**GE Wind**	**GE Wind**	**108**
Idaho	**Lewandoski wind farm**		**0.216**	**Bob Lewandoski**		**2**
Illinois	Mendota Hills	Lee County, near Mendota	50.4	Navitas Energy	Gamesa Eolica	63
Iowa	Flying Cloud	Near Spirit Lake	43.5	PPM Energy	GE Wind	29
Iowa	Henry Hills	Osceola County, near Sibley	3.6	Northern Alternative Energy	Gamesa Eolica	2
Iowa	Lenox	Lenox	0.75	Lenox Municipal	NEG Micon	1
Iowa	Wall Lake	Wall Lake	0.66	Wall Lake Municipal	Vestas	1
Iowa	Sibley Hills	Near Sibley	0.66	Northern Alternative Energy	Vestas	1

TABLE D-1 (Cont.)

State	Project Name	Location	Capacity (MW)	Developer	Turbine Manufacturer	No. of Wind Turbines
Minnesota	Chanarambie	Murray County	85.5	enXco	GE Wind	57
Minnesota	Moraine Wind Power Project	Pipestone & Murray Counties	51	PPM Energy	GE Wind	34
Minnesota	Farmers' cooperative corporations		22.8	DanMar & Associates	Suzlon Energy	24
Minnesota	McNeilus	Near Minn. Highway 56	22.8	Garwin McNeilus	NEG Micon	24
Minnesota	McNeilus		16.5	Garwin McNeilus	NEG Micon	11
Minnesota	Viking	Murray County	12	Project Resources		8
Minnesota	McNeilus		6	Garwin McNeilus	NEG Micon	4
Minnesota	Fairmont	Fairmont	1.9	SMMPA	NEG Micon	2
Minnesota	Missouri River Energy Systems	Worthington	1.9	Missouri River Energy Systems	NEG Micon	2
Minnesota	Shaokatan Power Partners	Lincoln County, near Hendricks	1.6	Northern Alternative Energy	Gamesa Eolica	2
Minnesota	McNeilus		1.65	Garwin McNeilus	NEG Micon	1
Minnesota	Don Sieve Wind Farm	Lincoln Co.	0.95	Diversified Energy Solutions	NEG Micon	1
Minnesota		Lincoln Co.	0.9	Diversified Energy Solutions	NEG Micon	1
Minnesota	Pipestone School District		0.75	Pipestone School District	NEG Micon	1
New Mexico	**New Mexico Wind Energy Center**	**Quay, DeBaca Counties**	**204**	**FPL Energy**	**GE Wind**	**136**
New Mexico	**Llano Estacado Wind Ranch at Texico**		**1.32**	**Cielo Wind Power**	**Vestas**	**2**

TABLE D-1 (Cont.)

State	Project Name	Location	Capacity (MW)	Developer	Turbine Manufacturer	No. of Wind Turbines
North Dakota		Near Edgeley	40.5	FPL Energy	GE Wind	27
North Dakota		Near Kulm	21	FPL Energy	GE Wind	14
Ohio		Bowling Green	3.6	Bowling Green Municipal	Vestas	2
Oklahoma	Blue Canyon Wind Power	North of Lawton	74.25	Zilkha Renewable Energy & Kirmart Corp.	NEG Micon	45
Oklahoma		Near Woodland	51	FPL Energy	GE Wind	34
Oklahoma		Near Woodland	51	FPL Energy	GE Wind	34
Oregon	**Combine Hills**		**41**	**Eurus**	**Mitsubishi**	**41**
Pennsylvania	Waymart	Clinton & Canaan Township	64.5	FPL Energy	GE Wind	43
Pennsylvania	Meyersdale	Somerset	30	FPL Energy	NEG Micon	20
South Dakota	Highmore	Near Highmore	40.5	FPL Energy	GE Wind	27
South Dakota	Rosebud Sioux		0.75	DisGen	NEG Micon	1
Texas	Brazos Wind Ranch	90 miles south of Lubbock	160	Cielo Wind Power/Orion Energy	Mitsubishi	160
Texas	Sweetwater	Sweetwater	37.5	DKR/Babcock-Brown	GE Wind	25
Texas	Hansford County, Texas		3	FPL Energy	Vestas	1
Texas	Indian Mesa		3		Vestas	1
Washington	**Nine Canyon, Phase II**	**Benton County**	**15.6**	**Energy Northwest**	**Bonus**	**12**
Wyoming	**Evanston**	**Evanston**	**144**	**FPL Energy**	**Vestas**	**80**

[a] Bold type indicates projects within the 11-state study area.

Source: Adapted from AWEA (2003b). Reprinted by permission. Courtesy of the AWEA.

TABLE D-2 Specifications for Wind Turbines Installed in 2003[a]

Parameter[b]	Ranges for Available Options[c]
Power (nameplate rating)[d]	200 kW–3.6 MW
Turbine type	Upwind HAWT
Cut-in speed (m/s)	2.5–4.0
Nominal wind speed (m/s)	11–16
Cut-out speed (m/s)	25
Rotor diameter (m)	30–104
Rotor-swept area (m^2)	706–8495
Rotor speed (rpm)	8–46
Rotor hub height (m)[e]	30–120
Tower construction material	Cylindrical or tubular steel, hot-dip galvanized lattice steel, combination concrete and tubular steel
Tower weight (kg)[f]	<30,500–216,780
Nacelle weight (excluding rotor) (kg)[e,f]	<19,954–55,329
Rotor weight (kg)[g]	<9,070–30,839
Total weight (kg)[h]	<37,188–158,300

[a] Data presented in this table represent the range of options offered by the manufacturers listed in Table D-1 for which data were readily available. No attempt was made to identify the specific turbine models used in the 2003 projects. Instead, all available models of the manufacturers listed were used to compute the ranges. Additional information on individual turbine models is available at that turbine manufacturer's Web site. Web sites are listed here as follows:

Atlantic Orient Corp.	http//www.aocwind.net/specs.htm
Bonus Energy Products	http//www.bonus.dk/uk/produkter/
Gamesa Eolica	http//www.gamesa.es/ingles/nucleos_negocio/gamesa_eolica/presentacion/presentacion.htm
GE Energy	http//www.gepower.com/businesses/ge_wind_energy/en/products.htm
Mitsubishi Electric	http//www.global.mitsubishielectric.com/bu/windpower/index2_b.html
NEG-Micon	http//www.neg-micon.com (Only limited data are available; data are not included in ranges presented in the table.)
Suzlon Energy	http//www.suzlon.com/technical_data
Vestas Wind Systems A/S	http//www/vestas.com/produkter/

[b] By industry convention, all specifications are presented in metric units.

[c] Range does not include data from AOC Model 15/50 turbine, the use of which has been confined to distributed energy systems in remote locations.

[d] Range represents individual turbine nameplate ratings. Additional specifications for power generation and management devices are available at the manufacturers' Web sites. However, since these devices have little or no influence on the environmental impacts of an operating wind turbine, they are not represented here.

[e] Rotor hub height is considered to be approximately equivalent to tower height, measured from ground elevation.

Footnotes continued on next page.

TABLE D-2 (Cont.)

[f] All weights are approximate; the weight range is based on models manufactured by Vestas Wind Systems A/S and Bonus Energy Products only. The weight of the smallest tower option was not available.

[g] Rotor weight includes active pitch control equipment, if present.

[h] Nacelle weights may differ as a result of drivetrain component selection.

Source: Derived from AWEA (2003b).

stipulations of a particular interconnection agreement with the transmission line operator. For the reader's convenience, the Web sites for the manufacturers whose turbines are represented in the range of values displayed are provided as footnotes to Table D-2.

The data displayed in Table D-1 appear to support the following conclusions about the characteristics of future wind farms. Notwithstanding the fact that calendar year 2003 was an exceptional year for industry growth, a reasonable assumption is that the projects that went on line in 2003 reflect the state of the technology with respect to commercially available wind turbines. Another reasonable assumption is that the wind turbine models installed in 2003 offered operating parameters that matched well with the specific conditions at the sites at which they were installed. A further assumption is that future sites with wind characteristics similar to those at sites developed in 2003 will utilize turbines with operating parameters similar to those displayed in Table D-2.

Following a strategy of extracting the maximum potential wind energy from a given site will minimize the overall environmental impacts. However, phased site development can cause changes to some impacting factors related to site development and operation. Some of the impacts in phased development will simply be additive over time. For example, the noise levels from individual turbines will be logarithmically additive for each turbine installed; however, because of the expected distances between turbines in a typical wind farm, the addition of each turbine will increase the area potentially impacted by noise, but it will not substantially increase the average or maximum noise levels throughout that area. Site topographic features can also greatly influence noise levels at a given distance from a noise source. See Section 4.5 of the PEIS for a detailed discussion on noise generation and propagation and Section 5.5 for a discussion on potential noise impacts from wind farms. Impacting factors associated with turbine foundations and erections will also be additive within a given phase of development and then reoccur during subsequent development phases, although not necessarily at the same magnitude or for the same duration. Other impacts related to initial site development may not reoccur at all during subsequent site expansions. For example, if it is assumed that the initial site development plan accounts for all future site expansions, a single main site access road can be selected and constructed as part of initial site development, and it can continue to serve as the site access road for subsequent phases of development. In such a scenario, only the expansions of on-site roads would be impacting factors in later development phases.

D.7 WIND ENERGY TECHNOLOGY RESEARCH AND DEVELOPMENT

A review of the current state of the commercial wind turbine market can provide a basis for predicting the types of turbines that are likely to be installed at future sites. However, it is also reasonable to predict that future site developers will avail themselves of technological advances and improved performance models. Therefore, a brief review of wind energy industry R&D activities is warranted. Although much of the R&D effort has been undertaken by the equipment manufacturers, the federal government also provides support. The discussions below are confined to R&D activities unique to the commercial wind energy industry. Note that R&D efforts to improve the design and performance of many of the major components of a wind turbine, such as transmissions and electrical generators, are also ongoing within the respective industry sectors. Likewise, R&D efforts in the general area of monitoring and control systems continue as well. Although these R&D efforts are not discussed here, it is assumed that wind farm developers and/or equipment manufacturers will incorporate technological advances from these other sectors into their wind farms and turbines at appropriate times.

D.7.1 Industry-Sponsored Research and Development

Leading equipment manufacturers are already engaged in R&D on many aspects of their products. Their primary objective is to maintain or improve their competitive positions in the markets in which they operate. R&D can also help them conform to quality standards (Section D.8).

Industry research focuses on improving the reliability of major components, improving overall efficiency, reducing manufacturing costs, and mitigating the adverse aspects of individual products. For example, manufacturers who hope to participate in the European wind energy market are exploring ways to mitigate the noise signals of their equipment. Because most wind farms in Europe are located close to inhabited areas, controlling noise is critical to maintaining market position. In its overview of worldwide wind energy industry trends, Shikha et al. (2003) found that continuous improvements were being made to applied technologies in the expanding wind energy industry. They found that energy output capacities of individual turbines increased 100-fold in the 15 years ending in 2003, while the overall weight of turbines was halved in the 5 years ending in 2003, and the noise emitted was halved over the 3-year period ending in 2003. Steady gains were attributed to a number of factors, including improved aerodynamics, improved structural dynamics, and improved micrometeorology, which resulted in precise turbine siting at the most ideal location. Additional improvements were attributed to the increase in rotor size and improved blade performance. Together with the benefits derived from reduced rotor weight, overall improvements in the drivetrain design and the reliability of individual components also resulted in a reduction in O&M costs. It is estimated that O&M costs constitute as much as 10 to 15% of the unit energy costs of a new wind farm; however, O&M costs increase to 20 to 30% near the end of the farm's design life (McGowan and Connors 2000). However, O&M costs are also expected to rise slightly over the design life of the turbine. Steady improvements in drivetrain design and efficiency are expected to reduce O&M costs from a U.S. average of $0.01/kWh in 1997 to $0.005/kWh by 2005 (McGowan and Connors 2000).

FIGURE D-8 Lattice-Type Wind Turbine Tower in South Dakota (A Vestas Model V17 wind turbine mounted on a lattice-type tower in Gary, South Dakota. Photo credit: Energy Maintenance Service, Inc., Sept. 1, 2002. Source: Photo # 12449, NREL 2004b.)

Manufacturers are also adopting modular design strategies that allow the replacement of individual turbine drivetrain components, thereby reducing downtime and costs. Often such strategies are further enhanced by equipping towers with internal lifting devices that allow the replacement of individual components without the necessity of bringing heavy-duty lifting devices to the site to remove the rotor assembly and/or the entire nacelle.

Although the majority of industry R&D initiatives focus on improving the design and efficiency of rotors and turbine drivetrain components, some innovative tower designs and materials can also affect future wind farms. Early wind farms utilized lattice-type towers (Figure D-8). However, smooth-skinned, tapered steel towers now dominate the commercial utility-scale market. The size and weight of the steel towers required for larger turbines increase installation costs and create significant problems related to the transportation of both the tower segments and the cranes required for their erection. A number of innovative tower designs and erection methodologies have been developed to overcome these impediments. Towers that can be erected by using mobile, temporary elevators have been developed, obviating the need for independent cranes and thus greatly simplifying erection costs and reducing transportation logistics (e.g., see Valmont 2004). A government-sponsored study completed in May 2001 identified a number of unique tower erection strategies and evaluated each against its impact on the overall cost of energy produced (Global Energy Concepts, LLC 2001). Two technologies were evaluated in depth and compared with conventional crane technologies. The study concluded that one of the two alternative erection methods compared favorably to conventional cranes for 1.5-MW and larger turbines, but it was more expensive than conventional cranes for smaller turbines. The study further postulated that alternative erection methodologies might be favored over conventional cranes for sites with complex terrain or difficult access, but they could be at a disadvantage at sites with significant wind shear. Other developments include constructing towers of tubular carbon composites in an integrated pyramidal shape, resulting in stronger and substantially lighter towers (e.g., IsoTruss Structures, Inc. 2004). Again, such lighter towers can substantially reduce transportation logistics and reduce site development costs.

D.7.2 Government-Sponsored Research and Development

Government-sponsored research and government-industry partnerships also account for a major portion of ongoing R&D efforts. DOE/EERE is the principal funding agency for government-sponsored research. Government participation also includes the personnel and facilities of NREL in Boulder, Colorado, and Sandia National Laboratories in Albuquerque, New Mexico. Government-industry partnerships proceed under the auspices of DOE's Cooperative Research and Development Agreement (CRADA) program. Under CRADA programs, government and industry collaborate to identify and better understand the fundamental science and engineering issues critical to technology advancement. Government personnel also conduct tests on prototypes and develop software that aids designers. Industries then have access to the published reports on CRADA research and use their contents to shape their own additional technology R&D. The government-industry partnership in DOE's Wind Energy Program is known as the Wind Partnerships for Advanced Component Technologies (WindPACT).[23]

DOE's R&D objectives and strategies are outlined in *Wind and Hydropower Technologies Program; Wind Energy Program Multi Year Technical Plan for 2004–2010* (EERE 2003). The overall strategic objective is to protect the nation's energy security by fostering the development of technologies that utilize a diverse supply of affordable and environmentally sound energy. Specific research objectives are defined in terms of reducing the ultimate costs of electricity generated by wind energy. Individual research initiatives, or technology improvement opportunities (TIOs), are distributed throughout all segments of the wind energy industry. The research initiatives of greatest importance to the utility-scale sector of the industry include improving the viability of low-wind-speed technology and facilitating the application of technologies and technological advances by engaging in fundamental research, developing quality standards and certification programs, conducting field verification tests, and analyzing and addressing technological and market impediments.

Researchers have identified a number of TIOs, including the following:

- Advanced drivetrain designs that use rare-earth permanent magnets for excitation, reduced gear box stages, and low- and medium-speed generators;
- Advanced power electronics that allow variable-speed operation while improving overall power capture/conversion efficiencies;
- Advanced rotors that use adaptive blades; and
- Advanced tower designs and materials that either reduce erection costs and simplify transportation logistics or are fabricated completely on site.

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[23] Many of the WindPACT technical reports may be accessed electronically at the NREL and Sandia Web sites; see NREL (2004a) and Sandia National Laboratories (2004d).

Research critical to the advancement of utility-scale turbines, especially in lower wind power classes,[24] includes the development of (1) advanced rotors; (2) a more complete understanding of a site's atmospheric dynamics; (3) improved generator, drivetrain, and power management subsystems; and (4) better integrated operational controls.

Turbines harvesting wind at lower wind classes are expected to need larger RSAs and operate at higher hub elevations. Rotor development focuses on the development of blades that are stiffer and stronger but also more slender, lighter, and more flexible (i.e., more adaptive to the dynamic forces they will encounter during operation). These apparently mutually exclusive characteristics hold the key to the successful advancement of large turbines. Although blade technology has already advanced significantly, it is thought that new materials and fabrication methods, as well as new design philosophies and criteria, will be necessary to support further substantial technological advances. Prototype blades made of long-fiber carbon composites are being tested for durability, and manufacturing processes are being refined.[25] If successful, this research will lead to turbines with greater RSAs and power-capturing efficiencies. There are, nevertheless, technical and economic limits to blade length. Rotor weight increases by the cube of its swept area, while the rated power efficiency increases by the square of the swept area. Consequently, there are some diminishing ROIs in the development of extremely long blades. Furthermore, with regard to extremely long blades, gravitational forces and torsional forces on the hub and the rotor shaft will become controlling forces in turbine design. Finally, as noted earlier, the torque produced by the rotor shaft increases with the square of the rotor diameter, thus significantly increasing the demand on transmissions and generators to withstand such increased torque moments. Some anticipate that the point at which these adverse forces will preempt rotor size expansions will be reached at rotor diameters of 256 ft (200 m), although the introduction of lightweight composites, such as fiber-reinforced plastics, may extend the practical rotor diameter to even greater values (Milborrow 2002).

Other possible dividends from increased blade length include lower operating costs and less aerodynamic noise. However, another real-world consequence of the use of very long blades is significant transportation logistics. Research conducted by Sandia and its contractor has explored the possibility of manufacturing turbine blades at the wind farm location (TPI Composites, Inc. 2003). The research concluded that on-site manufacturing was fraught with significant quality control issues and not feasible at this time. However, fabrication of the blades at nearby manufacturing sites (i.e., sites specifically constructed to support blade fabrication for use at a particular wind farm) was still considered feasible, since such a strategy would significantly reduce transportation distances and, if located judiciously, would significantly simplify transportation logistics. Other scaling and related logistics issues associated with transportation and erection also accompany any consideration for significantly enlarging wind turbines. WindPACT research initiatives will identify these obstacles and evaluate ways to overcome them.

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[24] Within the context of the WindPACT program, DOE defines lower wind classes as Class 4 and below (≤ 5.8 m/s [13 mpg] at a height of 10 m [33 ft]).

[25] See Sandia National Laboratories (2004c) for access to published reports of blade research being conducted by Sandia.

Up to this point of development, rotor aerodynamic design criteria have borrowed heavily from aerodynamic codes[26] developed in the aircraft industry. However, these codes do not reflect the aerodynamic conditions in which a wind turbine operates to a sufficiently high level of precision. New code development efforts are necessary to better understand the aerodynamic forces affecting both the performance and reliability of turbine rotor blades. Newly developed and validated codes will expedite the development of design criteria for longer, lighter, and more slender adaptive blades that can withstand dynamic forces and also impart minimum loads on the turbine drivetrain.

A more complete understanding of aerodynamic forces impinging on turbine blades will also allow designers to mitigate aerodynamic noise impacts. Another facet of research is the development of a semiempirical noise prediction code to be used by rotor and blade designers to ensure that new rotor systems have acceptable noise signatures.

As turbines become larger and operate at higher rotor hub heights, additional information about the atmospheric dynamics at these higher altitudes will be necessary to support design and micrositing decisions. It has already been established that the tallest turbines may be influenced by jet stream turbulence, especially by what are known as nocturnal jets (DOE 2002). Such turbulence is routinely present in low wind power classes, especially in the Great Plains regions. Successful advancement of wind turbines in such areas, especially in lower wind power classes, requires a much more complete understanding of jet stream turbulence and candidate site aerodynamics.

Other research initiatives on improving the power generation and management performance of the electric generator will have a direct impact on the interconnectivity of turbine power into the electrical grid but are expected to have little impact on environmental factors. Nevertheless, such improvements in overall turbine performance efficiency can be expected to reduce the mechanical noise emanating from the turbine blades and drivetrain components, as well as to reduce the number of breakdowns and maintenance shutdowns.

Finally, research on the advancement of integrated systems and controls attempts to enhance the precision with which turbines are monitored and controlled, promising better control of yaw and blade pitch to maximize performance. Such research pays its greatest dividends by improving the interconnection opportunities for wind farms. However, maintaining the turbine's operation at the highest performance level is also expected to improve overall reliability and reduce unwanted impacts that are manifestations of inefficiency (such as aerodynamic noise).

D.8 TESTING AND VERIFICATION PROGRAMS

DOE sponsorship of wind energy R&D also extends to field testing and verification programs. NREL and Sandia personnel, in collaboration with representatives of the Electric Power Research Institute (EPRI), other wind energy industry participants, and individual wind

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[26] Aerodynamic codes are an industry convention that describe the geometries of differently shaped airfoils.

farm operators, conduct evaluations of wind project development experiences and conduct field verifications of critical aspects of operational wind farms. The verification efforts help to identify issues related to site development, as well as design and operation, and provide the empirical basis for additional research on how to address or eliminate those issues. Published reports provide the opportunity for transferring lessons learned to other interested parties. Additional details about these verification programs and the published reports are available on the NREL and Sandia Web sites (NREL 2004c; Sandia National Laboratories 2004d).

D.9 STANDARDS AND CERTIFICATIONS

One clear indication of the maturation of the wind energy industry is the development and application of quality standards. International standards are already largely in place. Analogous U.S. standards are under development. Standards related to wind energy turbines promulgated by the International Electrotechnical Commission (IEC) are listed in Table D-3. The AWEA is the U.S. industry representative to this international standard-setting body. Many turbine manufacturers voluntarily conform to these standards to maintain their competitive position in the marketplace and to better guarantee the connectivity of wind-generated electric power to transmission grids. Conformance with international standards is a requirement for some wind farms in Europe.

U.S. wind energy industry consensus standards have been under development since 1974. The AWEA is the lead organization in domestic standard development. The development process involves the participation of various industry organizations, including the American Society of Mechanical Engineers (ASME), American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI), National Fire Protection Association (NFPA), American Gear Manufacturers Association (AGMA), and Institute of Electrical and Electronics Engineers (IEEE). Personnel from NREL and Sandia also participate in standards development. Domestic standards are expected to parallel and be compatible with IEC standards in order to ensure that American manufacturers maintain their access to European markets.

TABLE D-3 International Wind Turbine Standards

Standard No.	Title
IEC 61400-1	Wind Turbine Safety and Design
IEC 61400-1 Ed 2	Wind Turbine Safety and Design Revision
IEC 61400-2	Small Wind Turbine Safety
IEC 61400-12	Power Performance
IEC 61400-11	Noise Measurement
IEC 61400-13	Mechanical Load Measurements
IEC 61400-22	Wind Turbine Certification
IEC 61400-23	Blade Structural Testing
IEC 61400-21	Power Quality

In addition to quality standards for the design and construction of major turbine components, international standards are in place for the certification of turbines and ancillary systems by independent third-party auditors. Leading equipment manufacturers routinely submit their products and systems to such certifications so that they have evidence that their quality and performance goals have been met. Personnel from NREL are working in collaboration with Underwriters Laboratories, Inc. (UL) to develop analogous domestic certification standards and processes. Until those are in place, U.S. manufacturers are submitting their products and systems to certification against the international standards.

As the wind energy industry continues to mature, it is reasonable to expect that future wind farm developers and their equipment vendors will conform to applicable quality standards and submit their products and systems to third-party certifications. Conformance to quality standards and certifications provides a better guarantee of safe design and construction and generally increases both the reliability and performance of major wind turbine components. Given the levels of participation that already exist, it is reasonable to conclude that proposals for future wind farms and the equipment represented in those proposals will involve a commitment to conform to all applicable quality standards and to submit to all relevant third-party certifications.

D.10 IMPACTING FACTORS RELATED TO REASONABLY FORESEEABLE SITE DEVELOPMENT ACTIVITIES

The data in Tables D-1 and D-2 provide a reasonable representation of commercially available turbines and allow a reasonable prediction of the types of turbines that will be used in future sites. They are less adequate, however, in supporting further conclusions regarding site development. Nevertheless, past project experiences, together with the current state of wind energy technology and the advances expected from ongoing R&D activities, lend support to the following likely future site development scenarios.

- Business plans for future sites will involve developing candidate sites to their fullest wind energy potential as a means of quickly amortizing initial site development costs.

- The majority of large or extensive wind farms will probably be developed in phases, with the schedule of development being based largely on available development capital, as well as on myriad electric power market conditions. It is less likely that development will be speculative (i.e., built in advance of electric power sale agreements with transmission line operators) (Osborne 2004).[27]

[27] Nevertheless, speculative construction (sometimes referred to as a merchant plant) in advance of electric market agreements has occurred in the past.

- Sites developed in phases will not necessarily consist of the same turbine model throughout the site, and portions of the site may be owned and operated by more than one business entity.[28]

- Future sites are likely to take advantage of state-of-the-art wind turbine technology, leading to larger and taller but fewer turbines at a given site.

- It is possible that existing sites will expand into less-ideal areas that cannot, at this time, be economically farmed for wind energy by state-of-the-art turbine technologies.

- Sites may be repowered by replacing original turbines with technologically advanced models.[29]

- Modular construction of turbines will allow for their customization to address site-specific characteristics. Modular construction, together with sophisticated SCADA systems, now make it technically feasible for future farms to consist of various models of turbines operating at different elevations on the basis of site-specific wind regime characteristics.

- Site development strategies will take fullest advantage of economies of scale. Activities will be grouped by type (e.g., foundations for all planned turbines will be installed over the same period), thereby simplifying logistics.

- Although the majority of wind turbine construction will still occur at the manufacturer's facility, larger turbines, longer and more slender adaptive blades, and taller towers will impose unique problems related to the transportation of those components and may result in additional subassembly work being conducted on site during site construction.

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[28] The Foote Creek Rim site, located near Arlington, Wyoming, is an example of one possible wind farm development scenario. This project, which was initiated on BLM-administered land and has subsequently been expanded to adjacent non-BLM-administered lands, represents one of the most ideal wind regimes in existence, with average wind speeds in excess of 23 mph (37 km/h). Four separate wind farms have been developed by two separate developers, delivering electric power to three separate utilities. The first farm, completed in April 1999, involved the erection of sixty-nine 600-kW turbines built by Mitsubishi (Model 600) and distributed over a land area of 2,156 acres (872 ha). The footprints of the turbines, control buildings, and other structures make up less than 1% of the land area in the parcel. A second farm completed in June 1999 added an additional three Mitsubishi turbines and 1.8 MW of generating capacity. A third farm, also completed in June 1999, added 33 NEG Micon turbines, representing a capacity of 24.8 MW. A final phase of development, completed in October 2000, involved an additional 16.8 MW of capacity from an additional 28 Mitsubishi Model 600 turbines. The remainder of the parcel continues to be used for ranching, as was the case before the wind farm was constructed.

[29] Repowering is already occurring. Many of the wind farms constructed in California in the early 1980s have been repowered. See the attachment to this appendix.

- The use of innovative, self-erecting towers constructed of lightweight composite materials may dramatically minimize problems related to transportation logistics and site development times and costs. Reduced transportation requirements may expand the array of candidate sites to some that were previously excluded because of access difficulties.

- Equipment manufacturers can be expected to conform to international quality standards for manufacturing and operation (and to analogous U.S. standards as they are promulgated) as a way of maintaining market competitiveness. This conformance to standards will, in turn, lead to higher quality and greater reliability of major turbine components. Maintenance intervals are expected to increase as maintenance procedures become more regimented and are based on empirically derived isochronal factors rather than elapsed time.

- Sophisticated SCADA systems will allow wind turbines at a given site to operate independently of one another, enabling the economical development of sites with different wind regimes throughout.

- It will become increasingly feasible for wind farms to include ancillary technologies, such as battery charging and elevated water storage, which will allow for the delayed delivery of wind-generated electricity to the transmission grid.

- The expanded capabilities and operating ranges of turbines will allow economical harvesting of wind energy at sites with Class 3 wind regimes.

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Attachment to Appendix D:

Commercial Wind Energy Projects (as of January 2004)

Data on commercial wind energy projects in the western states that are within the scope of this programmatic environmental impact statement (PEIS) are displayed in the tables below. The American Wind Energy Association (AWEA) compiles and maintains all of the data displayed below. All data presented are current as of January 14, 2004. All data are accessible electronically from the AWEA Web site at http://www.awea.org/projects/index.html. Data presented in the tables below are updated quarterly by the AWEA.

The Bureau of Land Management (BLM) cannot guarantee the completeness or accuracy of these listings. Submission by wind farm developers or operators of project information to AWEA for inclusion in these listings is voluntary.

California

Major CA Wind Energy Resource Areas

Existing Project or Area	MW Installed*	Annual Energy Output (Yr of Est)	Power Purchaser/ User	Turbines
1. Altamont Pass	548.32	637 M kWh (1998)	Pacific Gas & Electric	Variety
2. Pacheco Pass	16.0	22.3 M kWh (1998)	Pacific Gas & Electric	Variety
3. San Gorgonio Pass	614.94	805 M kWh (1998)	So. California Edison	Variety
4. Solano County	176.16	N.A.	S.M.U.D	Kenetech & Vestas
	60.0	97.1 M kWh (1998)	Pacific Gas & Electric	U.S. Wind- power 100
5. Tehachapi	605.72	1.2 B kWh (1998)	So. California Edison	Variety
Others	0.675	N.A.	U.S. Navy	NEG-Micon

Wind Energy Projects in California

Project Name	Owner	Year	MW	Power Purchaser	Turbines / Units
Altamont Pass					
1985 Zond Windsystem Partners Series 85C	GE Wind	1985	18.0	PG&E	Vestas V-17 (200)
Venture Wind (old Los Vaqueros)	SeaWest	mid-1980's	2.89	PG&E	Polenko/ Wind-matic (38)
Altech Energy, Ltd	SeaWest	1981-1995	5.76	PG&E	Enertech (144)
C.W.E.S.	SeaWest	1981-1995	1.32	PG&E	Enertech (24)
SeaWest Energy Group (a)	SeaWest	1981-1995	0.065	PG&E	Micon (1)

		1995			(170)
Zond-PanAero Windsystems	GE Wind	1981-1995	29.9	So Cal Ed	Vestas V-15 (460)
Whitewater Hill (San Gorgonio Farms)	San Gorgonio Farms	1984 - 1994	31.0	So Cal Ed	DWT 400 (35), Bonus 120 (56), Vestas 500 (5), Bonus 65 (85)
Dutch Pacific	Dutch Pacific, LLC	1994	10.0	So Cal Ed	NedWind (20)
Karen Avenue (San Gorgonio Farms)	San Gorgonio Farms	1995	3.0	So Cal Ed	Vestas (6)
East Winds (formerly Altech III)	Nichimen America	1997	4.2	So Cal Ed	NEG-Micon (7)
Invest I-IX Project Web Site	K/S Whitewater	1999	10.0	So Cal Ed	Nordex (10)
Pacific West I	PacifiCorp	1999	2.1	SCE - Green Mt. Energy	NEG Micon - (3)
Cabazon (Re-power)	GE Wind	1999	39.75	So Cal Ed	Zond Z-750 (53)
Westwind (Re-power)	Cinergy & Caithness	May 1999	46.5	So Cal Ed	NEG Micon Project Info
GE Wind / Earth Smart/ Green Power	GE Wind	June 1999	16.5	Electricity Marketers	Zond Z-50 (22)
Westwind-Pacificorp (Re-Power)	Pacificorp/ GMER	May 1999	1.5	SCE - Green Mt. Energy	NEG-Micon (2)
Mountain View Power Partners II	PGE-NEG	Oct 2001	22.20	PG&E	Mitsubishi MWT600 (37)
Mountain View Power Partners I	PGE-NEG	Oct 2001	44.40	PG&E	Mitsubishi MWT600 (74)
Whitewater Hill	Shell Wind Energy	Dec 2002	61.50	Dept. of Water Resources	GE Wind Energy 1500 (41)
Cabazon	Shell Wind Energy	Dec 2002	40.92	Dept of Water Resources	Vestas V-47 (62)
Karen Avenue II	San Gorgonio Farms	June 2003	4.5	So Cal Ed	GE Wind Energy 1500 (3)
Mountain View III	San Diego Gas & Electric	4th Q 2003	22.44	San Diego Gas & Electric	Vestas 650 (34)

Solano County

Solano County/ Kenetech	NA	1985	60.0	PG&E	U.S. Wind-power (600)
Sacramento Municipal Utility District (SMUD)	SMUD	1994	3.6	Sac Mun Utility District	Kenetech (12)
SMUD	SMUD	1999	0.66	Sac Mun Utility District	Vestas (1)
SMUD	SMUD	2003	9.9	Sac Mun Utility District	Vestas 660kW (15)
High Winds	SMUD	2003	162	Sac Mun Utility District	Vestas 1.8 MW (90)

Tehachapi

Zond Systems	GE Wind	1986	0.2	So Cal Ed.	Vestas (1)
Victory Gardens, Phase IV	GE Wind	1990	22.05	So Cal Ed.	Vestas V-27 (98)
Sky River	GE Wind	1993	76.95	So Cal Ed.	Vestas V-27 (342)
Oak Creek Energy Systems	Oak Creek Energy Systems	2002	0.8	So Cal Ed.	NEG Micon (1)
Oak Creek Energy Systems	Oak Creek Energy Systems	1981-1995	3.45	So Cal Ed.	Micon (36)
AB Energy	NA	1981-1995	7.0	So Cal Ed.	Vestas V27 (31)
Calwind Resources	NA	1981-1995	14.1	So Cal Ed.	Bonus (217)
Calwind Resources	NA	1981-1995	8.7	So Cal Ed.	Nordtank (134)
Coram Energy Group	NA	1981-1995	1.9	So Cal Ed.	Aeroman (47)
Coram Energy Group	NA	1981-1995	4.0	So Cal Ed.	Aeroman (100)
Coram Energy Group	NA	1981-1995	6.8	So Cal Ed.	Aeroman / Tacke (110 / 4)
Mogul Energy	NA	1981-1995	4.0	So Cal Ed.	Mitsubishi (8)
Mohave 3, 4, 5	Tomen/ FPL	1981-1995	75.0	So Cal Ed.	Mitsubishi (300)
Mohave 16, 17, 18	Tomen/ FPL	1981-1995	85.0	So Cal Ed.	Mitsubishi (340)
Windridge	NA	1981-1995	2.34	So Cal Ed.	Windmatic (36)
Victory Gardens I & IV	NA	1981-1995	1.0	So Cal Ed.	Vestas (2)
Cannon	NA	1981-1995	13.46	So Cal Ed.	Micon, Vestas (8, 28)
Cannon (Various)	NA	1981-1995	4.54	So Cal Ed.	Micon, Vestas (42)
Ridgetop Energy	NA	1981-1995	32.6	So Cal Ed.	Nordtank, Micon (329)
Zond Systems	GE Wind	1982-1987	23.99	So Cal Ed.	Vestas (369)
Zond Systems	GE Wind	1982-1987	64.0	So Cal Ed.	Vestas (711)
Windland (Boxcar II)	Windland, Inc.	Mid-1980's	14.3	So Cal Ed.	Various (141)
Oak Creek Energy Systems	Oak Creek Energy	2002	1.35	So, Cal Ed	NEG Micon (1)

Oak Creek Phase 1 (ON Energy)	Nichimen & Oak Creek Energy	Sept 1997	4.2	So Cal Ed.	NEG Micon (7)
Oak Creek Phase 2A (Re-power)	Oak Creek Energy	June 1999	1.6	So Cal Ed	NEG Micon (2)
Pacific Crest	FPL Energy	Jun 1999	45.54	So Cal Ed	Vestas (69)
Oak Creek Wind Power Phase 2 (Repower)	Caithness	June 1999	23.1	So Cal Ed	NEG Micon-700 Project Info (33)
Cameron Ridge (Re-power)	FPL & Caithness	Mar 1999	56.0	So Cal Ed	NEG Micon (80) Project Info
Victory Gardens (Repower)	Enron Wind Corp.	Jun 1999	6.75	So Cal Ed	Zond Z-50 (9)

Others

U.S. Navy/ NEG Micon San Clemente Island	U.S. Navy	1998	0.675	U.S. Navy	NEG Micon (3)
Los Angeles Co.	Wind Turbine Company	2001	0.50	Southern Cal Ed.	WTC (1)

Planned Projects in California

Utility/Developer (Project)	Location	Status	MW Cap	Online date/ Turbine
PG&E/SeaWest (Venture Pacific)	Altamont Pass	Pending	25.6	2004 Mitsubishi
FPL/Green Ridge Power	Altamont Pass	Proposed Re-power	110.0	2004 NEG Micon - 700
Indigenous Global Development Corp.	Contra Costa	Proposed	22.50	NA / TBD
Pacific Ind Elec (San Clemente Is.)	San Clemente Is.	Under Dev	0.75	2004 NEG Micon
Mark Technologies (Alta Mesa IV)	San Gorgonio	Under Dev.	40.3	2004 Vestas - 660 kW
SMUD (Solano Wind Project - Phase I)	Solano	Under Development	9.24	2004 Vestas V-47
GE Wind (Victory Garden)	Tehachapi	Proposed	30.0	2004 GE Wind
Oak Creek Energy Sys (Jawbone)	Tehachapi	Proposed	52.5	2004

+ Uncertain completion dates

Colorado
Wind Energy Development

Project or Area	Owner	Date Online	MW	Power Purchaser/User	Turbines / Units
1. Ponnequin (EIU) (Phase I)	K/S Ponnequin WindSource & Energy Resources	Jan 1999	5.1	PSCo	NEG Micon (7)
1. Ponnequin (PSCo) Project Info	PSCo	Feb-June 1999	16.5	PSCo	NEG Micon (22)
1. Ponnequin (Phase III)	New Century (Xcel)	2001	9.9	New Century (Xcel)	Vestas (15)
Peetz Table Wind Farm	New Century (Xcel)	Sept 2001	29.7	New Century (Xcel)	NEG Micon (33)
Colorado Green, Lamar (Prowers County)	Xcel Energy / GE Wind Wind Corp.	Dec 2003	162.0	Xcel	GE Wind 1500 (108)

New Wind Projects in Colorado

Utility/Developer (Project)	Location	Status	MW Capacity	On Line By/ Turbines

None

Idaho
Wind Energy Development

Existing Project or Area	Owner	Date Online	MW	Power Purchaser/ User	Turbines/ Units
Boise	Bob Lewandowski	2003	0.216	NA	108 (2)

Planned Wind Projects in Idaho

Utility/Developer (Project)	Location	Status	MW Capacity	On Line By / Turbines

None

Montana
Wind Energy Development

Existing Project or Area	Owner	Date Online	MW	Power Purchaser/ User	Turbine
Blackfeet Reservation	Blackfeet Nation	1996	0.1	Glacier Electric Cooperative	Vestas V-17 (1)

New Wind Projects in Montana

Utility/Developer (Project)	Location	Status	MW Capacity	On Line / Turbine
Assiniboine & Sioux Tribes / Montana-Dakota Utilities (Fort Peck Reservation Wind Project	Fort Peck Res/ Poplar MT	Under Dev.	0.66	2004/ Vestas V-47 660kW

Nevada

Wind Energy Development

Existing Project or Area	MW Installed*	Annual Energy Output (Yr of Est)	Power Purchaser/ User

None

New Wind Projects in Nevada

Utility/Developer (Project)	Location	Status	MW Capacity	On Line By/ Turbine
Global Renewable Energy Partners & BP Capital (Power Star) (Table Mountain)	Near Primm in Sandy Valley	Proposed	105.0	2004 / NEG Micon
Cielo Wind Power (Desert Queen Wind Ranch)	Clark County	Proposed	60.0	2005
Global Renewable Energy Partners (Ely Wind LLC)	White Pine County	Proposed	50.0	2005 / NEG Micon

New Mexico

Wind Energy Development

Existing Project or Area	Owner	Date Online	MW	Power Purchaser/ User	Wind Turbines
1. Curry County (Llano Estacado Wind Ranch at Texaco)		June 1999	0.66	Excel	Vestas V-48 (1)
SW Public Service (Clovis)	Texas Wind Power	June 1999	0.66	Southwestern Public Service	Vestas V-47
New Mexico Wind Energy Center	**FPL Energy**	2003	**204**	Public Service of New Mexico	GE Wind 1500 (136)
Llano Estacado Wind Ranch	**Cielo Wind Power**	4th Q 2004	**1.32**	PS of New Mexico	Vestas 660 kW (2)

New Wind Projects in New Mexico

Utility/Developer (Project)	Location	Status	MW Capacity	On Line By
None				

Oregon
Wind Energy Development

Existing Project or Area	Owner	Date Online	MW	Power Purchaser/ User	Turbines/ Units
1. Vansycle Ridge (Helix, OR)	FPL Energy	Oct 1998	25.1	Portland General Electric	Vestas V-47 (38)
Condon Wind Project Phase I (Gilliam County)	TBA	Dec 2001	24.6	BPA	Mitsubishi MWT600 (41)
Klondike (Wasco)	Northwest Wind Power	Dec 2001	24.0	Northwest Wind Power	Enron 1.5MW (16)
Stateline Wind Project, (Umatilla)	FPL Energy; Vansycle	Dec 2001	83.16	PacifiCorp	Vestas V-47 (127)
Condon Wind Project Phase II (Gilliam County)	TBA	Dec 2002	25.2	Bonneville Power Administration	Mitsubishi MWT600 (42)
Stateline (Orphans)	FPL Energy Vansycle LLC	2002	37	NA	Vestas V47 (55)
Combine Hills	PacificCorp/ Eurus	Dec 2003	41.0	PacificCorp	Mitsubishi 1000 (41)

New Wind Projects

Utility/Developer (Project)	Location	Status	MW Capacity	On Line By / Turbines
None				

Utah
Wind Energy Development

Existing Project or Area	Owner	Date Online	MW	Power Purchaser/ User	Wind Turbine/ Units
Camp Williams, Riverton	U.S. Gov't	May 2000	0.225		NEG Micon / (1)

New Wind Projects in Utah

Utility/Developer (Project)	Location	Status	MW Capacity	On Line By / Turbine
None				

Washington State
Wind Energy Development

Existing Project or Area	Owner	Date Online	MW	Power Purchaser/ User	Turbines/ (Units)
Stateline Wind Project, Phase I (Walla Walla)	FPL Energy, Vansycle	Dec 2001	180.2	PacifiCorp	Vestas V-47 (273)
Nine Canyon Wind Farm	Energy Northwest	Sep 2002	48.0	Public Power Members of Energy Northwest	Bonus 1300 (37)
Walla Walla County	Stateline Wind	2002	39.6	NA	NA
Nine Canyon Phase II	Energy Northwest	4th Q 2003	15.6	Energy Northwest	Bonus 1300 (12)

New Wind Projects in Washington State

Utility/Developer (Project)	Location	Status	MW Capacity	On Line By
BPA / Pacific Winds (Maiden Wind Farm)	Benton & Yakima Co. near Presser	Proposed	150.0	2004
BPA / Pacific Winds (Horse Heaven Hills)	Benton Co.	Proposed	150.0	2004
Zilkha Renewable Energy (TBD)	Near Ellensburg / Kittitas County	Proposed	100.0	2004
BPA / SeaWest Wind Power (Roosevelt)	Klickitat County	Speculative	150.0	2004
BPA / SeaWest Wind Power (Six Prong)	Klickitat County	Speculative	150.0	2004
BPA / SeaWest Wind Power (Waitsburg)	Walla Walla / Columbia	Speculative	100.0	2004
BPA / Columbia Windpower (Columbia Wind Ranch)	Klickitat Co.	Speculative	80.0	2004

Wyoming

Wind Energy Development

Existing Project or Area	Owner	Date Online	MW	Power Purchaser/ User	Turbines/ Units
Medicine Bow	PRPA±	1996	0.065	PRPA	Nordtank (1)
1. Medicine Bow, WY	PRPA	1998	1.2	PRPA	Vestas (2)
1. Foote Creek Rim - I (Carbon Co.)	Pacificorp, Eugene Water & Elec.	April 1999	41.4	Pacificorp, EWEB	Mitsubishi (69)
1. Foote Creek Rim - II (Carbon Co.)	Cinergy Global (Part Interest)	June 1999	1.8	BPA	Mitsubishi (3)
1. Foote Creek Rim - III	Cinergy Global	June	24.75	Public Service	NEG Micon

(Carbon Co.)	Power	1999		Co of Colorado	(33) Project Info
1. Foot Creek Rim - IV (Carbon Co.)	Cinergy Global Power	Oct 2000	16.8	BPA	Mitsubishi 600 (28)
1. Medicine Bow	PRPA	Oct 1999	3.3	PRPA	Vestas V-47 (5)
1. Medicine Bow	PRPA	July 2000	1.32	PRPA	Vestas V-47 (2)
Arlington, Carbon Co. (Rock River I)	Shell Renewables	Oct 2001	50.0	PacifiCorp	Mitsubishi MWT (50)
Evanston	FPL Energy/Orion Energy	4th Q 2003	144.0	PPM Energy	Vestas 1800 (80)

+ Platte River Power Authority

New Wind Projects in Wyoming

Utility/Developer (Project)	Location	Status	MW Capacity	On Line By / Turbines
None				

Notes:
No commercial wind energy projects are operational or planned for Arizona.
Only those wind energy projects that interconnect to the electric transmission system are listed.
Unless otherwise specified, all data are current as of January 14, 2004.